Quantum optics in ordered atomic arrays

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Dissipation is a pervasive problem in many areas of physics. In quantum optics, losses curb our ability to realize controlled and efficient interactions between photons and atoms, which are essential for many technologies ranging from quantum information processing to metrology. Spontaneous emission - in which photons are first absorbed by atoms and then re-scattered into undesired channels - imposes a fundamental limit in the fidelities of many quantum applications, such as quantum memories and gates. Typically, it is assumed that this process occurs at a rate given by a single isolated atom. However, this assumption can be substantially violated: interference in photon emission and absorption generates correlations and entanglement among atoms, thus making dissipation a collective phenomenon. In this talk, I will discuss the physics of subradiance, a form of collective dissipation in which interference is destructive and atomic decay is inhibited. Exploiting subradiant states of ordered atomic arrays allows for the realization of a quantum memory with a photon retrieval fidelity that performs dramatically better with number of atoms than previously known bounds [1,2]. This single example illustrates how ordered arrays transcend the "standard model" of disordered atomic ensembles. Time permitting, I will also discuss collective effects in ordered chains of atoms with non-trivial hyperfine structure [3].

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